

ELECTRICALLY CONTROLLED EXHAUST VALVE

BACKGROUND OF THE INVENTION

- [1] This invention generally relates to an exhaust system for a motor vehicle having a variable displacement engine, and specifically to an exhaust valve disposed within the exhaust system for controlling noise emissions from the exhaust system.
- [2] A variable displacement engine controls actuation of specific cylinders within an engine. Typically, all cylinders of an multiple cylinder engine are providing power at all times during operation of the vehicle. Under some driving conditions, power produced from all cylinders is not required to propel the vehicle. The variable displacement engine shuts down some of the cylinders to conserve fuel and increase gas mileage. During periods of low engine demand only half of the cylinders operate to propel the vehicle. The selective actuation of engine cylinders provides the most noticeable improvements in fuel efficiencies for larger vehicles with larger engines.
- [3] Selective actuation of specific cylinders of an engine produces an undesirable side effect. The change in engine displacement alters sound emitted from the exhaust system. Typically larger engines are installed in larger more expensive vehicles. Consumers purchasing such vehicles have certain performance expectations. During operation of the vehicle with a reduced number of cylinders the sound emitted from the exhaust system may not convey the desired sound expected by the consumer.
- [4] It is known to provide a valve within an exhaust system to reflect a portion of exhaust flow back through the engine to condition sounds from the exhaust system. Actuation of the valve is provided by a vacuum powered actuator. The vacuum powered actuator utilizes vacuum supplied by the engine through flexible hoses or tubes routed

under the vehicle. The underside of a vehicle is a particularly harsh environment. Disadvantageously, the flexible hoses used to supply vacuum to the actuator become brittle and crack with age resulting in vacuum leaks and malfunction of the actuator.

- [5] Accordingly, it is desirable to develop a system for conditioning noise from an exhaust system to provide a consistent desired noise from the engine regardless of changes in engine displacement with improved dependability.

SUMMARY OF INVENTION

- [6] This invention is an exhaust system for a motor vehicle including an exhaust valve that is actuatable to block a portion of an exhaust pipe to reflect sound waves to condition sound emitted from the exhaust system.

- [7] The exhaust valve of this invention includes a valve plate moveable about an axis within a valve body. The valve body is disposed within an exhaust pipe before or after a muffler. The placement of the valve body is dependent on the desired sound of the exhaust system. The valve plate is actuated by an electric actuator mounted within a housing.

- [8] The housing for the actuator is supported a distance from the exhaust pipe by a valve neck. The valve neck is a tubular member having flanges at each end. The tubular configuration of the valve neck reduces the amount of thermal energy transmitted from the exhaust pipe to the housing. Electric actuators are dependable and relatively inexpensive, and are therefore more desirable than alternatively powered actuators. The reduction in thermal conduction between the valve body and the support housing prevents a substantial amount of heat from radiating to the electric actuator. The

exhaust system of a vehicle produces high temperatures that present a challenge to the use of an electric actuator. It is for this reason that the exhaust valve of this invention includes features that isolate the electric actuator from thermal energy produced by the exhaust pipe.

- [9] Accordingly, the exhaust valve assembly of this invention utilizes an electric actuator to provide conditioning of noise emitted from the exhaust system to provide a consistent desired sound regardless of changes in engine displacement.

BRIEF DESCRIPTION OF THE DRAWINGS

- [10] The various features and advantages of this invention will become apparent to those skilled in the art from the following detailed description of the currently preferred embodiment. The drawings that accompany the detailed description can be briefly described as follows:
- [11] Figure 1 is a cut away view of an exhaust valve assembly according to this invention;
- [12] Figure 2 is a cross sectional view of the exhaust valve assembly according to this invention;
- [13] Figure 3 is a cut away view of the support housing and actuator according to this invention;
- [14] Figure 4 is a top cut away view of the exhaust valve of this invention;
- [15] Figure 5A a top cut away view of an exhaust valve according to this invention with a rotary actuator; and
- [16] Figure 5B is a side view of the rotary actuator.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[17] Referring to Figure 1, an exhaust system 10 includes an exhaust pipe 12. Exhaust gases 16 flow through the exhaust pipe 12 after being discharged from combustion cylinders of an engine. The exhaust gases 16 resonate through the exhaust pipe 12 to emit a distinctive sound. The sound differs with the displacement of the engine. In applications where the engine provides variable displacement by selectively actuating and de-actuating cylinders depending on the driving conditions, the noise emanating from the exhaust system 10 varies in response to changes in displacement. It is desirable for sounds emanating from the exhaust system 10 to have a consistent sound regardless of the displacement of the engine. To provide this consistent sound, an exhaust valve assembly 11 is actuated to change the function of the exhaust system dependent upon engine displacement.

[18] An exhaust valve assembly 11 is disposed within the exhaust system 12. The exhaust valve assembly 11 includes a valve body 14 that is installed within the exhaust pipe 12. The valve body 14 houses a valve plate 24 that rotates about an axis of rotation 23 between an open and closed position. In the open position the valve plate does not block a noticeable portion of exhaust flow 16. In the closed position, the valve plate 24 preferably blocks between 75% and 90% of the exhaust flow 16. As appreciated, the specific amount of exhaust flow blocked by the valve plate 24 is tailored to a specific application to produce the desired consistent sound. The specific portion of exhaust flow 16 blocked by the valve plate 24 provides control of sound emitted from the exhaust system 10.

[19] Partially blocking the flow of exhaust 16 through the exhaust pipe 12 creates an increase in backpressure. The increase in backpressure reflects sound waves back within the exhaust system 10. Reflecting the sound waves provides for the control of sounds from the exhaust system 10. Preferably, the sound of the exhaust system 10 is controlled to duplicate the sounds of the engine at the largest displacement regardless of the actual displacement at which the engine is operating.

[20] The exhaust valve 11 of this invention includes an electric actuator 22. The electric actuator 22 is provided to provide the mechanical force for operation of the exhaust valve assembly 11. As appreciated electric actuators are durable and have relatively long operational life. Further, electric actuators are easily integrated into current vehicle configurations. The electric actuator 22 is housed within a support housing 38. The support housing 38 is spaced a distance from the valve body 14 by a valve neck 20. The valve neck 20 includes a first flange 26 attached to the valve body 14 by bolts 28. Between the flange 26 and bolts 28 are seals 30. The seals 30 thermally isolate the valve neck 20 from the valve body 14.

[21] A heat shield 18 is attached to the exhaust pipe 12 by straps 19 between the exhaust 12 and the actuator 22. The heat shield 18 is spaced a distance from the pipe 12 to create an air space 17 (Figure 2) that aids in shielding heat from being emitted toward the actuator 22.

[22] Referring to Figure 2, the exhaust valve assembly 11 is shown in cross section such that the heat shield 18 can be seen spaced apart from the exhaust pipe 12. The space 17 between the heat shield 18 and exhaust pipe 12 reduces radiant heat emitted from the exhaust pipe 12 toward the actuator 22.

- [23] The valve neck 20 includes the first flange 26 that is attached to the valve body 14. The first flange 26 and bolts 28 include seals 30 disposed on either side of the first flange 26. The seals 30 inhibit conduction of thermal energy into the valve neck 20. The valve neck 20 includes a tubular portion 54. The tubular portion 54 substantially reduces the amount of heat transmitted from the exhaust pipe 12 to the support housing 38. The support housing 38 includes a plate 40 disposed between the actuator 22 and the exhaust pipe 12.
- [24] An actuation tube 32 is attached to the valve plate 24 and extends through the valve neck 20. The actuation tube 32 is hollow and rotates about the axis of rotation 23. Rotation of the actuation tube 32 is accomplished by linear movement of the actuator 22. The configuration of the actuation tube 32 also inhibits transmission of heat from the valve body to the actuator 22. The actuation tube 32 is cylindrical and hollow. Air disposed and flowing through the hollow actuation tube inhibits the transfer of thermal energy from the exhaust pipe 12.
- [25] The actuator 22 includes a first pull coil 21 and a second hold coil 25. The first pull coil and the second hold coil 25 are of differing configurations to provide differing magnitudes of force. The first pull coil 21 provides a higher force than the second hold coil 25. The actuator 22 must exert sufficient force to overcome pressures biasing the valve plate 24 toward the open position from the exhaust flow 16. The first pull coil 21 produces a force to initiate movement of the valve plate 24 against the exhaust flow 16. The second hold coil 25 produces less force than the first pull coil 21 and is of a lesser strength to utilize less power. The use of a reduced force coil provided by the second hold coil 25 is possible because maintaining the position of the valve plate 24 once the

initial forces of the exhaust flow 16 are overcome are lower. A worker with the benefit of this disclosure will recognize that other actuator configuration can be used to control the valve plate 24.

[26] Referring to Figure 3, the support housing 38 encloses a clevis assembly 42. The clevis assembly 42 links the actuator 22 with the actuation tube 32. The actuator 22 includes a linear member 27 extendable from the actuator 22. A spring 52 is disposed to bias the linear member 27 towards a position that causes the valve plate 24 to move to its most open position. The spring 52 provides a default position in which the exhaust valve assembly 11 will move in the event of an actuator malfunction.

[27] The clevis assembly 42 includes a clevis 44 attached to the linear member 27. The clevis 44 moves linearly in response to movement of the linear member 27. A lever arm 50 is attached and fixed to the actuation tube 32. Movement of the lever arm 50 causes rotation of the actuation tube 32. The lever arm 50 includes a slot 48. A pivot 46 connects the clevis 44 with the lever arm 50. The movement of the pivot 46 within the slot 48 enables radial movement of the lever 50 in response to linear movement of the linear member 27 and clevis 44. Slot 48 is required to allow the radial movement of the lever 50 about the axis of rotation 23. As appreciated the clevis assembly 42 is only one possible link configuration within the contemplation of this invention. A worker skilled in the art with the benefit of this disclosure would understand that other configurations for converting movement of the actuator 22 to rotation of the actuation tube 32 are suitable for use with this invention.

[28] Referring to Figure 4, the valve neck 20 is shown with a first end 34 attached to the valve body 14. A second end 36 is attached to the support housing 38. The valve

neck 20 and support housing 38 both include cross-sections 37,39 disposed in a direction transverse to the exhaust pipe 12. The cross-section 37 of the valve neck 12 transverse to the exhaust pipe is smaller than the cross-section 39 of the support housing 38 in a direction transverse to the exhaust pipe 12. The support housing 38 includes the plate 40. The plate 40 also acts as a secondary heat shield between the actuator 22 and the exhaust pipe 12. This is in addition to the heat shield 18 that is wrapped at least partially around the exhaust tube 12. The actuator 22 is partially exposed to the elements. This exposure provides some cooling benefits to the actuator 22.

[29] Moving parts such as the clevis assembly 42 and the linear member 27 of the actuator 22 are housed within the support housing 38. The support housing 38 encloses the clevis assembly 42 and the moving parts of the actuator 27 to prevent debris and other contaminants from fouling the system. As appreciated the exhaust system 10 is mounted to the under carriage of a vehicle. This is an especially hostile environment for most devices. The support housing 38 necessarily protects the moving parts from contamination and debris that can foul and damage the operating components of the exhaust valve assembly 11. Although the actuator 22 is partially exposed it is shielded by the plate 40 from heat radiating from the exhaust pipe 12.

[30] Referring to Figures 5A and 5B, an exhaust valve assembly 11' according to this invention includes a rotary actuator 56. The rotary actuator 56 is attached to rotate the actuation shaft 32. A torsion spring 58 is attached to the actuation shaft 32 to bias the rotary actuator 56 and actuation shaft 32 toward a position causing the valve plate 24 to move to the most open position. As appreciated, a worker having the benefit of this

disclosure would understand that other electric actuators could be used to move the valve plate 24.

[31] The actuator 22 is also isolated from heat emanating from the exhaust pipe 12 by the tubular portion 52 of the valve neck 20. Isolation of the actuator 22 from heat emitted by the exhaust pipe 12 enables the utilization of the electric actuator 22. The exhaust valve assembly 11 of this invention provides a durable, cost effective means of conditioning exhaust noises for variable displacement engines.

[32] The foregoing description is exemplary and not just a material specification. The invention has been described in an illustrative manner, and should be understood that the terminology used is intended to be in the nature of words of description rather than of limitation. Many modifications and variations of the present invention are possible in light of the above teachings. The preferred embodiments of this invention have been disclosed, however, one of ordinary skill in the art would recognize that certain modifications are within the scope of this invention. It is understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described. For that reason the following claims should be studied to determine the true scope and content of this invention.